fixed to the end of a small indiarubber tube in order to be laid near the insect whose notice it may be desired to attract. FRANCIS GALTON

PRELIMINARY NOTE ON THE BACILLUS OF TUBERCULOSIS (KOCH)

I. THE absorption and consequent retention of certain stains by this bacillus does not appear to be effected by the hydrates of potassium, sodium, and ammonium and by aniline alone. Sodic phosphate, potassic acetate, vegetable alkaloids, &c., appear to exert a similar action. Further experiments are in progress. I have some very good preparations which were rapidly stained with a *very faintly* coloured stain containing sodic phosphate (sod. phos. cryst. B.P.).

II. The sections of tissue shown (by the kind arrangement of Mr. Blaker) at the Brighton meeting of the British Medical Association, in which the bacilli were very distinct, were stained, &c., then floated on to the glass slides, *dried over concentrated sulphuric acid* (or fused $CaCl_2$), and mounted in balsam. Hitherto my attempts to fix the colour of the bacilli, by means of a mordant, in such a way that it might remain unaffected by alcohol, and by oil of cloves, have not proved successful.

III. Treatment with a solution of potassic acetate will probably prove well adapted to free preparations from those last traces of nitric acid which so often cause their ultimate destruction.

From (II.) I should omit a very beautiful and remarkable preparation showing the spores of this bacillus in the lymphatics of the lung. This slide was prepared by Dr. Barron, of University College, Liverpool, and for his kindness in lending it to me and for much invaluable advice I am very grateful.

To Mr. Blaker, M.R.C.S., of Brighton, and to Mr. Black, M.R.C.S., of the Sussex County Hospital, I am under many obligations for their kindly interest and assistance. J. W. CLARK

THE SHAPES OF LEAVES[1]

III.—*Origin of Types*

THE two most general and distinctive types of foliage among angiosperms are those characteristic of monocotyledons and dicotyledons respectively. They owe their principal traits of shape and venation to the manner in which these two great fundamental classes have been separately evolved from lower ancestors.

Mr. Herbert Spencer has shown that there are two chief ways in which a central axis or caulome may conceivably be developed from an integrated series of primitive stalkless creeping fronds. The *first* way is by the in-rolling or folding of the fronds so as to form a complete tube, often with adnate edges, as represented in the accompanying diagram (Fig. 20), modified by Mr. Spencer's kind permission from the "Principles of Biology." For details of the explanation, the reader must be referred to that work (vol. ii. part iv. chap. iii.); it must suffice here to note that as in such case each frond must envelop the younger fronds within it, the process is there shown to eventuate in an endogenous stem and a monocotyledonous seed—two characteristics found as a matter of fact constantly to accompany one another in actual nature. The *second* way is by the thickening and hardening of a fixed series of midribs, as shown in the next diagram (Fig. 21), also modified after Mr. Spencer; and this method must necessarily result in an exogenous stem and a dicotyledonous seed. The diagrams in Figs. 22 and 23, which represent according to Mr. Spencer (slightly altered) the development of the monocotyledonous and dicotyledonous seedling respectively, will help further to illustrate the primitive characteristics of the two types.

The monocotyledonous type of foliage is for the most part extremely uniform and consistent, in temperate climates at least, for in the tropics the presence of large arborescent forms, such as palms and screw-pines, as well as of gigantic lilies, amaryllids, and grasses, such as the bananas, yuccas, agaves, and bamboos, gives a very distinctive aspect to the *ensemble* of the class. Being in principle a more or less in-rolled and folded frond, every part of which equally aids in forming the caulome or stem, the monocotyledonous leaf tends as a rule to show little distinction between blade and leaf-stalk, lamina and petiole. For the same reason, the free end also tends to assume a lanceolate or linear shape, while the lower part usually becomes more or less tubular or sheathing in arrangement. Again, for two reasons, it generally has a parallel venation. In the first place, since the leaves or terminal expansions are mere prolongations or tips to the stem-forming portion, it will follow that the vascular tissues will tend to run on continuously over every part, instead of radiating from a centre which must in such a case be purely artificial. In the second place it is clear that parallel venation is the most convenient type for long narrow leaves, as is plainly shown even among dicotyledons by such foliage as that of the plantains, descended from netted-veined ancestors, but with chief ribs now parallel. Still better are both these principles illustrated in those cases among dicotyledons where the lamina is suppressed altogether, and the flattened petiole assumes foliar functions, as in *Oxalis bupleurifolia* and *Acacia melanoxylon* (Fig. 24). These phyllodes thus resembling in their mode of development the monocotyledonous type, and continuous throughout with the caulome-portion of the primitive leaf, exhibit both in shape and venation the chief monocotyledonous characteristics. A typical monocotyledon in shape and venation is represented in Fig. 25.

The dicotyledonous type, though far more varied, is equally due in its shape and venation to the original characteristics implied by its origin. Only the midrib instead of the whole leaf being here concerned in the production of the stem, there is a far greater tendency to distinctness between petiole and lamina, and a marked preference for the netted venation. The foliar expansion is not here a mere tip; it becomes a more separate and decided element in the entire leaf. And as the petiole joins the lamina at a distinct and noticeable point, there is a natural tendency for the vascular bundles to diverge there, making the venation palmate or radiating, so as to distribute it equally to all parts of the expanded surface. Fig. 26 shows the resulting characteristic form of dicotyledonous leaf. Its variations of pinnate or other venation will be considered a little later on.

Among monocotyledons, the central type is perhaps best found in the mainly tuberous or bulbous orders, such as the orchids, lilies, and amaryllids. These orders, having rich reservoirs of food laid by underground, send up relatively thick and sturdy leaves; but their shape is decided by the ancestral type, and by their strict subordination to the central axis. Hence they are usually long, narrow, and rather fleshy. Familiar examples are the tulips, hyacinths, snowdrops, daffodils, crocuses, &c. Those which have small bulbs, or none, or grow much among grass, like Sisyrinchium, are nearly or quite linear; those which raise their heads higher into the open, like Listera, are often quite ovate. Exotic forms (bromelias, yuccas, agaves) frequently have the points sharp and piercing, as a protection against herbivores. In the grasses there is generally no large reservoir of food, and their leaves accordingly show the central type in a stringy drawn-up condition. So also in sedges, woodrushes, and many others. But where the general monocotyledonous habit has been more lost, and something

[1] Continued from p. 466.

like the dicotyledonous habit acquired, the leaves become more like those of the opposite class. Thus the Arums, with their very unlilylike mode of growth, and their long petioles rising high into the open air, have usually a very distinct broad lamina, and have the veins accordingly branched or netted, almost as in dicotyledons. Very much the same type recurs under similar circumstances in *Sagittaria sagittifolia* (Fig. 27). Still more markedly dicotyledonous-looking are the leaves of certain very aberrant Amaryllids, such as *Tamus* and the other Dioscorideæ, which have taken to climbing, and have therefore acquired broader leaves with netted veins between the ribs. Compare with these the like result in *Smilax;* and then look at both side by side with such dicotyledons as *Convolvulus.* The influence of the ancestral type is here seen in the arrangement of the main ribs; the influence of environment is shown both in the approximation of general shape, and in the netting of the minor veins. Once more, the ovate type of Listera leads on readily enough to the whorled leaves of *Paris* and *Trillium*, where the venation has become similarly netted. A bushy type, like *Ruscus*, develops broad leaf-like peduncles, which closely simulate the true leaves of dicotyledonous bushes with like habit, such as box or privet.

FIG. 20.—Developmen of Monocotyledonous stem.

FIG. 21.—Development of Dicotyledonous stem.

But the widest departure of all from the central monocotyledonous type is found in leaves like those of the tropical arborescent forms—the palms, screw-pines, &c. Most of these have long pinnate foliage, whose origin may best be considered when we come to examine the chief dicotyledonous types; meanwhile such forms as the cocoanut or the date-palm may be advantageously compared, as to conditions and general shape, with the treeferns in one direction, and the cycads in another. The bananas cast much analogous light upon the origin of these tropical pinnate forms. Where the plant is less arborescent, as in *Chamærops*, the leaf assumes rather a fan-shaped than a pinnate development.

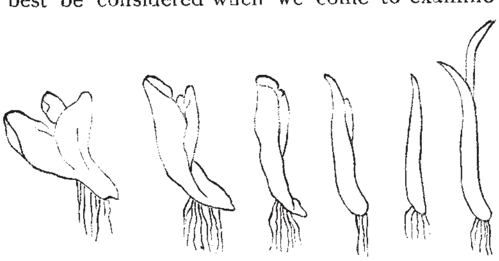


FIG. 22.—Development of Monocotyledonous seedling.

Among dicotyledons it may be fairly assumed that the earliest form of leaf was simple, ovate, and nearly ribless, or with faint digitate venation. This is shown both by the nature of the earliest leaves in most seedlings, and the constant recurrence to such a type wherever circumstances are favourable for its reproduction. Hence, as a whole, digitate venation seems the commonest in most humble dicotyledons; and the only problem is how pinnate venation came to be substituted for it in certain cases. The answer seems to be that wherever circumstances have caused leaves to lengthen faster than they broadened, and so to assume a lanceolate rather than an ovate shape, the tendency has been for the main ribs to be given off, not from the same point, but a little in front of one another. If the technical botanists will pardon such a phrase, the internodes of the midrib, usually suppressed, seem here to have been fully developed. Figs. 28, 29, and 30 show the stages by which such a change

may be brought about. Figs. 31, 32, and 33 exhibit a slightly different form of the same tendency.

That this is the real origin of pinnate venation seems pretty clear on a comparison of a good many otherwise closely related forms. Look for example first at the rounded, almost orbicular leaf of *Geranium molle* and its allies,

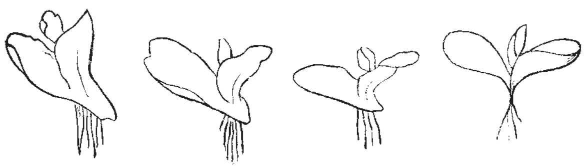


FIG. 23.—Development of Dicotyledonous seedling.

with palmate ribs; and then look at the long, narrower, doubly pinnate, and pinnately-ribbed leaves of *Erodium cicutarium*. Or again, look at the common cinquefoil, erect and palmate; and then at silver-weed, long, creeping, closely pressed to the ground, and with numerous pinnate leaflets. Once more, compare *Alchemilla* with

FIG. 24.—*Acacia melanoxylon*.

Poterium and *Sanguisorba*. As a still simpler instance, where we get the difference in its first beginning, contrast *Ranunculus acris* with *R. repens*, or the least compound leaves of the blackberry bramble with its own most compound foliage. As a rule the most pinnate groups, such

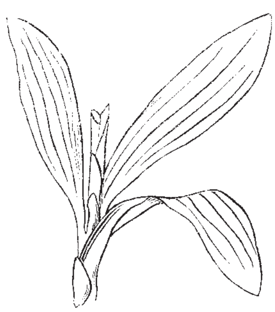


FIG. 25.—Typical Monocotyledonous leaves and venation.

as the lesser crucifers, the peaflowers, &c., have very long leaves.

This suggested origin of pinnate venation in dicotyledons becomes even more probable when we look at the pinnate members of other classes. Among monocotyledons the long-leaved arums, though their venation is fundamentally parallel in type, have yet acquired a branching and practically pinnate set of ribs. The plantains and bananas, with very long and broad foliage, carry the same tendency yet further; for their leaves are pinnately ribbed from a stout midrib. The lower shrubby or bushy palms, like Chamærops, have fan-shaped leaves, with veins diverging in rough parallelism from a common centre; that is to say, they are in fact palmate; but in the taller arborescent palms, with their long leaves, the internodes of the midrib (to use the same convenient

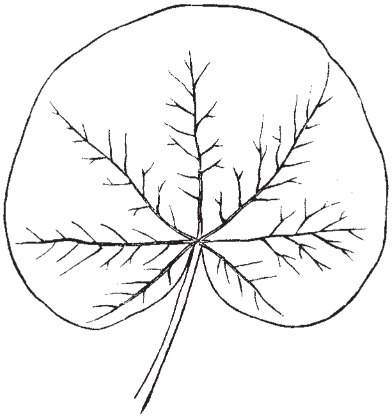


FIG. 26.—Typical Dicotyledonous leaf and venation.

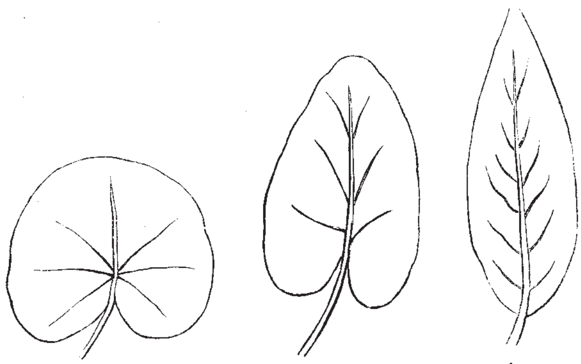
phrase once more) are fully developed, so that the leaf becomes pinnatifid. In this case the subdivision into leaflets is probably protective against tropical storms. The broad-leaved plantains and the Chamærops, though so much shorter than the pinnate palms, are often torn by the wind, and a plantain leaf so torn into ribbons closely resembles a cocoanut leaf: in the taller palms this disruption between the ribs becomes normal. Compare Zamia and the other cycads among gymnosperms.

FIG. 27.—*Sagittaria sagittifolia*.

Once more, the ferns are a class with long lanceolate fronds as a rule, and their venation is almost always pinnate; the only ferns that vary much from the central type being some like the Maidenhairs, which are tufty and rather ovate in general form, and have so modified their venation as closely to approach the herb Roberts and other hedgerow plants in the outer effect. We may

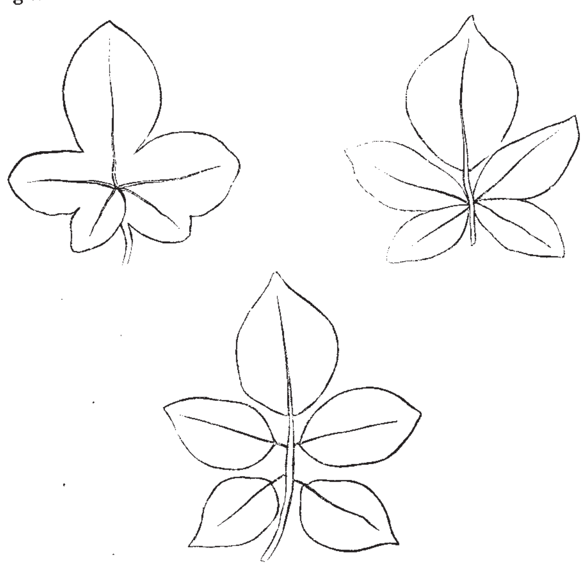
fairly conclude, therefore, that pinnate venation is best adapted to very long leaves, both because of the support it gives to the cellular mass and because of the easy manner in which it distributes sap to every part alike.

It seems also probable that pinnate ribs are especially adapted to forest trees. Most of these indeed have their leaves rather long in outline—like the ash, the oak, the chestnut, the walnut, the mountain ash, the laurels, the hornbeam, and the willow—while others in which the primary ribs are palmate—like the horse-chestnut and



FIGS. 28, 29, 30.—Gradation from palmate to pinnate venation.

the plane—have their secondary ribs pinnate and their lobes or leaflets very long, so that the total effect is in the end pretty much the same. But even when the leaf is rather shortened in general outline, as in the elm, the beech, the alder, and the poplar, the venation is still pinnate. Doubtless this form of ground-plan protects the leaves of these exposed trees best against the wind; and where the leaflets are much subdivided, as in the acacias, the subdivision may be regarded as a protection against severe storms.



FIGS. 31, 32, 33.—Gradation from palmate lobes to pinnate leaflets.

The shapes of leaves in each particular species of plant thus depend in ultimate analysis upon two factors: first, the ancestrally-inherited peculiarities of type and venation; and second, the actual conditions to which the species is now habitually exposed. Accordingly, under the same conditions, a monocotyledon and a dicotyledon will tend to assume approximately similar general external forms; but their underlying ancestral peculiarities may generally be perceived through the mere analogical resemblance produced by an identical environment. By the interaction of the two factors we must endeavour to explain every particular form of leaf. To do this throughout the whole vegetable kingdom would be of course an endless task, but to do it in a few selected groups is both a practicable and a useful botanical study. The ground-plan will always depend upon the ancestral type; the outline, degree of segmentation, and minuteness of cutting, will always depend upon the average supply of carbonic acid and sunlight. GRANT ALLEN

(*To be continued.*)

NOTES

SIR JOHN LUBBOCK did right to ask the Prime Minister on Monday, whether, in remodelling the department of the Lord President of the Council, he would consider the desirability of separating the actual Minister of Education in the House of Commons from that office, and of transferring to him the power of appointing the inspectors and other officers on whom the satisfactory working of the education of the country so greatly depends. As might have been expected, Mr. Gladstone held out no hope of any change being made for a long time; that, however, is no reason why the efforts of the friends of science and education in this direction should cease.

THE Grocers' Company have issued a scheme for the encouragement of original research in sanitary science. It consists of two forms of endowment: the one, meant as maintenance for work in progress, in fields of research to be chosen by the worker himself; the other, meant as reward for actual discovery in fields of research to be specified from time to time by the Company. With the former intention the Company establishes three Research Scholarships, each of 250*l*. a year; with the latter intention they appoint a Discovery Prize of 1000*l*., to be given once in every four years. The Research Scholarships are intended as stipends for persons engaged in making exact researches into the causes of important diseases, and into the means by which the respective causes may be prevented or obviated. The Court of the Company propose to appoint to two of the scholarships in May, and to a third in May, 1884. The Discovery Prize is intended to reward original investigations, which shall have resulted in important additions to exact knowledge, in particular sections of sanitary subject-matter. The Court will, once in four years, propose some subject for investigation; and the first subject will be announced in May.

THE Annual Report of the City and Guilds of London Institute, taken in conjunction with the Annual Meeting held last week, shows that technical education has taken firm root and is making rapid progress in this country. Though hardly yet so universal as on the Continent, there is every reason to believe that it soon will be, and Lord Selborne, who presided at the Annual Meeting, was justified in congratulating the Institute on its success. As the *Times*, in a sensible article on the Annual Meeting, says: "Lord Selborne did not dwell at length upon the general aspects of technical education. He assumed, and he had good reason to assume, that the need for a systematic development of it is proved beyond question, and is almost universally accepted. No observer now doubts that if the English artisan is to hold his ground in the struggle for existence, he must be kept up to the mark by proper teaching; and no one who has at heart the moral well-being of the working classes doubts the enormous importance of giving them an insight into principles and processes which will raise their work as much as possible out of the mere mechanical groove."

THE following are the arrangements for the lectures after Easter at the Royal Institution:—Prof. J. G. McKendrick, ten lectures on physiological discovery; Dr. Waldstein, four lectures on the